

(19) World Intellectual Property  
Organization  
International Bureau



542856

(43) International Publication Date  
26 August 2004 (26.08.2004)

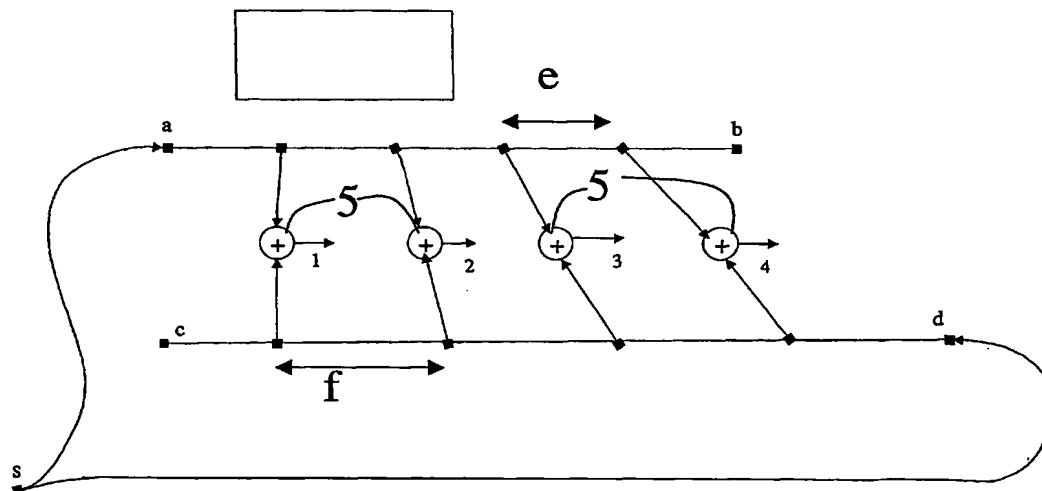
PCT

(10) International Publication Number  
**WO 2004/073110 A1**

- (51) International Patent Classification<sup>7</sup>: **H01Q 3/26**
- (21) International Application Number:  
PCT/FI2004/000069
- (22) International Filing Date: 13 February 2004 (13.02.2004)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:  
20030234 14 February 2003 (14.02.2003) FI
- (71) Applicant (for all designated States except US):  
VAISALA OYJ [FI/FI]; P.O. Box 26, FIN-00421 Helsinki (FI).
- (72) Inventor; and
- (75) Inventor/Applicant (for US only): KARHUNEN, Pentti  
[FI/FI]; Luhtatie 38, FIN-02760 Espoo (FI).
- (74) Agent: SEPPÖ LAINE OY; Itämerenkatu 3 B,  
FIN-00180 Helsinki (FI).
- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.
- (84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).
- Published:  
— with international search report  
— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

[Continued on next page]

(54) Title: METHOD AND APPARATUS FOR CONTROLLING POWER DIVISION IN A TRAVELLING-WAVE ANTENNA



(57) Abstract: This publication discloses a method and apparatus for feeding signal power to an antenna array comprising several antenna elements (1 - 4). According to the method, the signal power is fed to the antenna elements (1 - 4) over two transmission lines (a-b) and (c-d), in which case the divisions (e) of one of the transmission lines (a-b) are shorter than the nominal wavelength and those (f) of the other (c-d) are longer than the nominal wavelength by the same amount, the signal s being fed is divided into two parts, one of which is led to one of the said two transmission lines (a) and the other to the opposite end (d) of the other line, in which case the signals travel in the lines in opposite directions, and the signals are summed (5) before the antenna elements (1 - 5).

WO 2004/073110 A1



---

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

## **Method and Apparatus for Controlling Power Division in a Travelling-wave Antenna**

The present invention relates to a method, according to the preamble of Claim 1, for controlling power division in a travelling-wave antenna.

The invention also relates to an apparatus for controlling power division in a travelling-wave antenna.

The invention is intended to permit a desired form of amplitude distribution when feeding the transmission line of a travelling-wave antenna alternately from each end, in order to turn the lobe of the antenna to two different positions.

### **The prior art and its drawbacks**

In a travelling-wave antenna, power is distributed to the radiating antenna elements along a serial line (Figure 1), in which the phase of the signal going to the antenna elements (1, 2, 3, and 4) from one end (a) depends on the lengths of the parts of the transmission line and the amplitude on the division ratios of the connection points. If the transmission-line parts are of a length that is exactly the wavelength, the phase difference between the antenna elements will be zero, and the lobe of the antenna will be aligned perpendicular to the plane of the antenna elements.

If the length of the parts of the transmission line differs from the wavelength, there will be an equal phase difference between all the antenna elements, and the lobe of the antenna will turn away from the perpendicular position. If the transmission line is fed from the other end (b), the said phase difference will have the opposite sign, and the lobe will turn to the other side of the perpendicular position. Thus, the lobe of the antenna array can be turned to two positions, by using a suitable switch to change the direction of travel of the signal.

If the transmission line is fed from only one end a, the division ratios of the line can be

dimensioned to give the antenna elements the desired amplitude distribution. If a transmission line designed in this way is fed from the other end b, the division ratios will no longer be the previous ones, while the characteristics of the lobe created will not be those desired. If the division ratios are to remain identical when the line is fed from both ends, a constant division ratio must be applied in the divisions of all the antenna elements, 1, 2, 3, and 4, which will result in the exponential diminution of the amplitude distribution. The side-lobe level of the antenna array will then increase.

The invention is intended to eliminate the defects of the state of the art disclosed above and for this purpose create an entirely new type of method and apparatus for controlling the power division of a travelling-wave antenna. By means of the solution according to the invention, the lobe of a travelling-wave antenna can be turned to two directions using a transmission line fed from different ends, so that the drawbacks described above are mostly avoided.

The invention is based on using two parallel transmission lines, the divisions of one of which being shorter than the nominal wavelength and those of the other being longer than the nominal wavelength by the same amount, dividing the signal s being fed into two parts, one of which is directed to one of the two said transmission lines a and the other is directed to the opposite end d of the other line, so that the signals travel in opposite directions in the lines. In that case, the signals will be in the same phase at the corresponding divisions in the transmission lines. The same-phase signals diverging from points corresponding to the position of the divisions of the transmission lines are summed and directed to the antenna elements 1, 2, 3, and 4.

More specifically, the method according to the invention is characterized by what is stated in the characterizing portion of Claim 1.

The apparatus according to the invention is, in turn, characterized by what is stated in the characterizing portion of Claim 3.

Considerable advantages are gained with the aid of the invention.

- The amplitude distribution is identical in both positions of the antenna lobe.
- Altering the division ratio allows the amplitude distribution to be optimized, in order to achieve the desired characteristics of the lobe.

In the following, the invention is examined with the aid of examples and with reference to the accompanying drawings.

Figure 1 shows a schematic diagram of the feed line of a travelling-wave antenna according to the prior art.

Figure 2 shows a schematic diagram of a dual-travel-wave feed line according to the invention.

Figure 3 shows graphically the amplitude distribution of the transmission lines, when using a constant division.

Thus, in the solution according to the invention, operation is as follows:

1.) In the solution, two parallel transmission lines are used, the divisions *e* of one being shorter than the nominal wavelength and the divisions *f* of the other being longer by the same amount than the nominal wavelength (Figure 2). Thus, when the signal travels in the lines, in the same direction, the phase-differences arising in the divisions will be opposite.

The power-division ratios of the transmission lines are typically at least approximately identical.

2.) The signal *s* being fed is divided into two parts, one of which is directed to the end *a* of the transmission line *a-b* and the other to the opposite end *d* of the other line *c-d*, so that the signals travel in opposite directions in the lines. In that case, the signals will be

in the same phase at the corresponding divisions.

3.) The same-phase signals diverging from the corresponding points at the locations of the divisions of the transmission lines are summed in a summing unit 5 and directed to the antenna elements 1, 2, 3, and 4. Thus, when using constant power-division ratios, the amplitude distribution of both lines will be identically exponentially diminishing (Figure 3). Due to the summing that takes place in the summing amplifier 5 preceding the antenna elements 1, 2, 3, and 4, the final amplitude distribution is symmetrical. If it is wished to reduce the side-lobe level of the antenna array, the signals from the divisions 1, 4 at the ends of the transmission line are directed to the centre of the antenna array and from the divisions 2, 3 in the centre to the outer ends of the array (Figure 3), as the amplitude of the signal is greatest at the divisions at the ends. The final amplitude distribution can be controlled by altering the division ratio of the divisions.

4.) If it is wished to alter the direction of the lobe, the transmission lines are altered to feed from the point b and c, in which case the signals will travel in a different direction, though the mutual phase-differences will remain the same at the points 1, 2, 3, and 4. In practice, this change in feed takes place with the aid of a switch, which is not shown. Because the amplitude distribution is symmetrical, it will remain identical in both positions of the antenna lobe, when the direction of travel of the signal is altered. If it is wished to reduce the side-lobe level of the antenna array, the signals from the divisions 1, 4 at the ends of the transmission line are directed to the centre of the antenna array and from the divisions in the centre to the outer ends of the array, because the amplitude of the signal is greatest at the divisions at the ends. The final amplitude division can be controlled by altering the ratio of the divisions.

**Claims:**

1. A method for feeding signal power to an antenna array comprising several antenna elements (1 - 4), which method is **characterized** in that

- two parallel transmission lines (a-b) and (c-d) are used, in which case the divisions (e) of one (a-b) of the transmission lines are shorter than the nominal wavelength and those (f) of the other (c-d) are longer than the nominal wavelength by the same amount,
- the signal s being fed is divided into two parts, one of which is directed to one of the said two transmission lines (a, (a-b)), and the other to the opposite end of the other line (d, (c-d)), so that the signals travel in the lines in opposite directions, and
- the signals are summed (5) before the antenna elements (1 - 5).

2. A method according to Claim 1, **characterized** in that the direction of the lobe created by the antenna elements (1, 2, 3, 4) is changed by feeding the transmission lines ((a-b), (c-d)) from their opposite ends (b, c), in which case the signals travel in a different direction in the transmission lines, but the mutual phase-differences remain essentially unchanged.

3. An apparatus for feeding signal power to an antenna array comprising several antenna elements (1 - 4), which apparatus includes

- several antenna elements (1 - 4), and
- two transmission lines (a-b) and (c-d) for feeding signal power to the antenna elements,

**characterized by**

- the divisions (e) of one of the transmission lines (a-b) being shorter than the nominal wavelength and those (f) of the other (c-d) are longer than the nominal wavelength by the same amount,
- means for dividing the signal s being fed into two parts, one of which is directed to one of the said two transmission lines (a, (a-b)) and the other is directed to the opposite end of the other line (d, (c-d)), so that the signals travel in the lines in

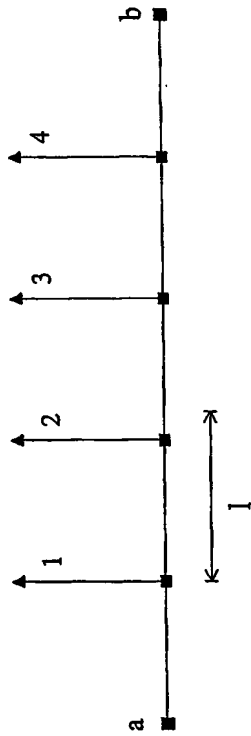
opposite directions, and

-summing elements (5), by means of which the signals coming from the different transmission lines can be summed before the antenna elements (1 - 5).



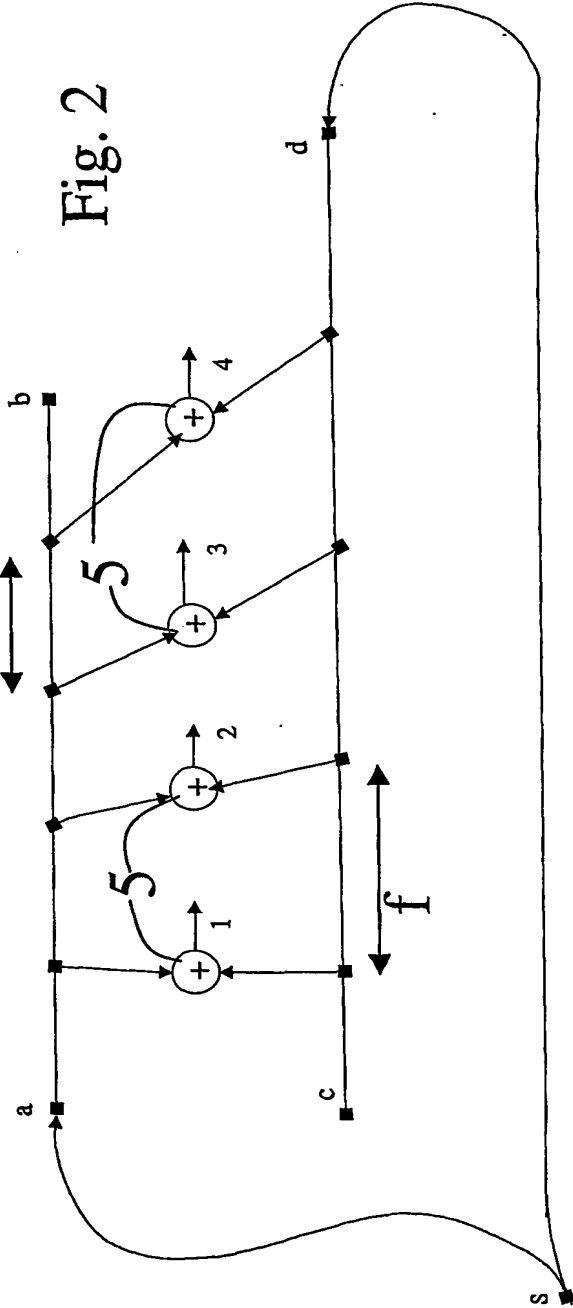
1/2

Fig. 1



e

Fig. 2



2/2

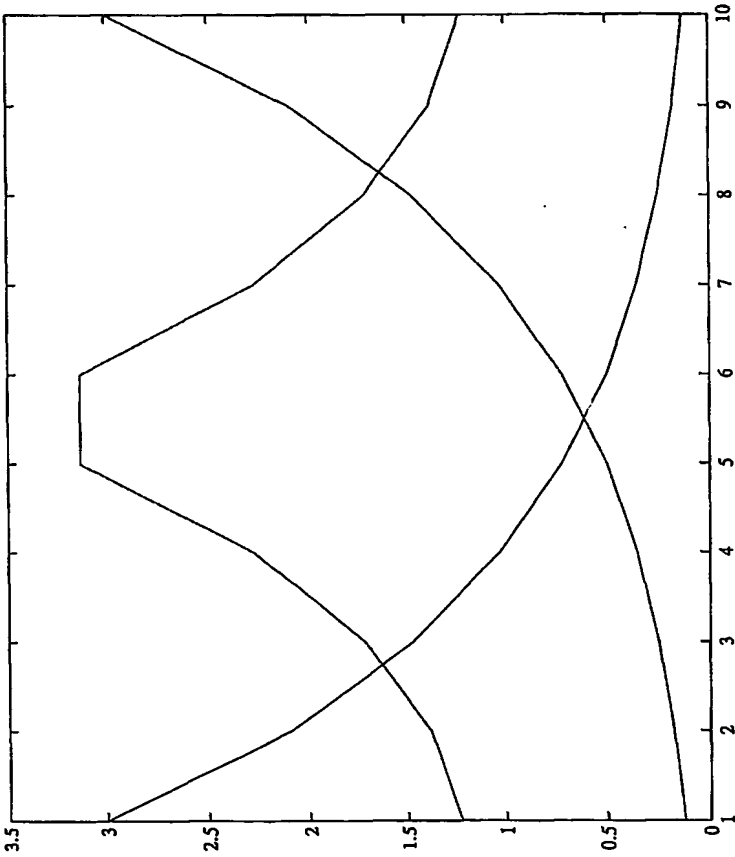


Fig. 3

# INTERNATIONAL SEARCH REPORT

10/54285(6)

International application No.

PCT/FI 2004/000069

## A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H01Q 3/26

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H01Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5210541 A (HALL, P. ET AL), 11 May 1993 (11.05.1993), see the whole document --	1-3
A	US 4780723 A (MEAD, J.B.), 25 October 1988 (25.10.1988), see the whole document --	1-3
A	US 4605931 A (MEAD, J.B. ET AL), 12 August 1986 (12.08.1986), see the whole document --	1-3
A	US 4529988 A (JAMES, J.R. ET AL), 16 July 1985 (16.07.1985), see the whole document -- -----	1-3

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

\* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

18 June 2004

Date of mailing of the international search report

21-06-2004

Name and mailing address of the ISA/  
Swedish Patent Office  
Box 5055, S-102 42 STOCKHOLM  
Facsimile No. +46 8 666 02 86

Authorized officer

Rune Bengtsson /OGU  
Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT  
Information on patent family members

30/04/2004

International application No.

PCT/FI 2004/000069

US	5210541	A	11/05/1993	DE	69014607 D,T	13/04/1995
				EP	0456680 A,B	21/11/1991
				SE	0456680 T3	
				GB	8902421 D	00/00/0000
				JP	2977893 B	15/11/1999
				JP	4503133 T	04/06/1992
				WO	9009042 A	09/08/1990
<hr/>						
US	4780723	A	25/10/1988	AU	587869 B	31/08/1989
				AU	6443586 A	27/08/1987
				CA	1262574 A	31/10/1989
				DE	3705141 A	27/08/1987
				FR	2595010 A	28/08/1987
				GB	2187043 A,B	26/08/1987
				GB	8625662 D	00/00/0000
				IL	80388 D	00/00/0000
				IT	1199767 B	30/12/1988
				IT	8622692 D	00/00/0000
				JP	62200803 A	04/09/1987
				NO	864568 A	24/08/1987
				SE	8700005 A	22/08/1987
<hr/>						
US	4605931	A	12/08/1986	AU	576240 B	18/08/1988
				AU	4227485 A	20/03/1986
				CA	1234621 A	29/03/1988
				DE	3531474 A	27/03/1986
				FR	2571551 A,B	11/04/1986
				GB	2164498 A,B	19/03/1986
				GB	8510171 D	00/00/0000
				IL	75041 A	31/01/1989
				IT	1200682 B	27/01/1989
				IT	8521641 D	00/00/0000
				JP	1768846 C	30/06/1993
				JP	4049802 B	12/08/1992
				JP	61072405 A	14/04/1986
				NO	165568 B,C	19/11/1990
				NO	852003 A	17/03/1986
				SE	461492 B,C	19/02/1990
				SE	8504123 A	15/03/1986
<hr/>						
US	4529988	A	16/07/1985	EP	0086558 A	24/08/1983